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Original article

The acute effects of vibration stimulus following FIFA 11+ on agility and reactive strength in collegiate soccer players

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Abstract

Purpose: The aim of this study was to assess the effects of combining the FIFA 11+ and acute vibration training on reactive strength index (RSI) and 505 agility.

Methods: Seventy-four male collegiate soccer players took part in the study and were randomly assigned to FIFA 11+ with acute vibration group (FIFA + WBV), FIFA 11+ with isometric squat group (FIFA + IS) or a control group consisting of the FIFA 11+ alone (Con). The warm-up consisted of the FIFA 11+ and was administered to all participants. The participants in the acute vibration group were exposed to 30 s whole body vibration in squat position immediately post warm-up. The isometric group completed an isometric squat for 30 s immediately post warm-up.

Results: RSI significantly improved pre- to post-intervention amongst FIFA + WBV ($p < 0.001$) due to a decrease in contact time ($p < 0.001$) in comparison to FIFA + IS and Con, but 505 agility was not affected.

Conclusion: The results of this study suggest the inclusion of an acute bout of WBV post FIFA 11+ warm-up produces a neuromuscular response leading to an improvement in RSI. Future research is required to examine the exact mechanisms behind these improvements amongst other populations and over time course of the performance.

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Keywords: Agility; FIFA 11+; Reactive strength; Soccer; Vibration

1. Introduction

Soccer is one of the most popular sports worldwide; it is a contact sport and challenges physical fitness by requiring a variety of skills at different intensities. Running is the predominant activity, and explosive efforts during sprints, duels, jumps, and changes of direction are important performance factors, requiring maximal strength and anaerobic power of the neuromuscular system.^{1–4} The physiological and technical demands of the sport lead coaches and clinicians to continually look for the best methods of preparation for the athletes to perform at their optimum.

The completion of an active warm-up before training or physical competition has typically been shown to have a positive impact on athletic performance with improvement in power, speed, and agility.^{5–7} Contemporary research has identified the importance of a dynamic warm-up on improving reactive strength and jumping ability in soccer.⁷ An effective warm-up, however, should not just be seen as essential to performance but also as a mechanism to reduce incidence of injury amongst players. Compliance with specific dynamic warm-up protocols, such as the FIFA 11+, have been shown to decrease injury risk amongst youth soccer players.⁸ However, the FIFA 11+ warm-up, although well established as a means of reducing injuries, has been reported as not having an effect on performance outcomes in soccer players.^{1,9,10} Vescovi and VanHeest¹¹ suggested that developing warm-up protocols, with not only injury prevention benefits but also performance benefits, would make it easier to convince coaches to implement

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such programmes. Some researchers have discussed additions to the FIFA 11+ warm-up protocol to help realise performance enhancements.¹⁰ Impellizzeri et al.,¹⁰ however, pointed out that any such additions to the FIFA 11+ need to consider fatigue (worsening of performance) and time efficiency to the soccer player. Although the FIFA 11+ has been traditionally investigated over a longer period of time, Zois et al.¹² has encouraged researchers to challenge traditional warm-up routines in soccer and how they subsequently effect acute physical qualities of the players.

Soligard et al.⁸ raised some important issues when it comes to successful warm-up programme to improve performance and reduce injury risk; what is crucial is compliance from the athlete and the coach. Time constraints are seen as a perceived barrier for many coaches to the implementation of a specific warm-up protocol and the perceived increase in workload.⁸ As such whole body vibration (WBV) exercise is an acute application that can easily be administered and has been previously identified as an ideal dressing-room based intervention in soccer. It has also been identified as a possible counter to any cool down period between pitch based warm-up and performance, or as a useful addition during tactical discussions.¹³

Recent investigation has identified acute WBV as a viable method of improving speed in soccer.^{14,15} Turner et al.¹⁶ found that an exposure of 30 s at 40 Hz was sufficient to elicit a positive change in explosive power amongst recreationally trained males. Their findings are particularly attractive to coaches and players due to the short time frame required to elicit a positive response. In particular the acute effects of WBV training have become a popular area of research amongst strength and conditioning coaches and sports scientists due to its time efficiency and other potential benefits.^{17–20} McBride et al.²⁰ asked participants to complete six acute sets of bilateral/unilateral squats at a frequency of 30 Hz (3.5 mm amplitude) and identified an increase in peak force of the triceps surae during maximal voluntary contractions. Bullock et al.¹⁹ reported the addition of 3 × 60 s WBV at a frequency of 30 Hz post warm-up amongst elite skeleton athletes as being beneficial to subsequent sprint and maximal jump performances.

The above research highlights the possible contribution of post activation potentiation (PAP) as a possible mechanism for the improvements in performance and highlighted its possible benefits as a pre-competition routine.²⁰ PAP is a proposed condition where pre-exercise muscle stimulation leads to an increase in motor neuron excitability and/or increased phosphorylation of myosin light chains.^{21–24} It also has been reported as being elicited by WBV.²⁵ More recently this has been questioned, particularly when looking at acute vibration studies. Increases in the short-latency stretch reflex response of the stretch shortening cycle have been identified as a possible factor in the increase in power production post vibration stimulus at higher vibration stimulus >40 Hz.²⁴ The benefit of this to soccer would be that the initial PAP following WBV would help prepare the player for the intense engagement and that high tempo play associated with the first 15 min of the match;²⁶ this in turn is also identified as a period of the game with a high injury occurrence.²⁶ Towlson et al.²⁷ reported

pressuring opponents, establishing match tempo and asserting superiority as key priorities in this period. When implementing a warm-up or half-time warm-up in professional soccer these are the main factors considered by practitioners for the first 15 min of each half.²⁷

The positive impact of a well-structured dynamic warm-up (FIFA 11+) on reducing injury risk has been reported. The effect this protocol has had on subsequent performance has, however, been questioned, with some researchers recommending additions to the programme to improve performance gains.¹⁰ The present study aims to identify if vibration stimulus added any extra performance benefit to a dynamic warm-up or was a standard dynamic warm-up protocol sufficient to elicit a positive acute response in performance in collegiate soccer players. The study examines whether adding acute WBV or isometric exercise to the FIFA 11+ has an effect on reactive strength index or 505 agility performance.

2. Methods

2.1. Participants

Seventy-four male collegiate amateur soccer players volunteered for the study (20.0 ± 1.2 years, 74.1 ± 14.8 kg, and 174.5 ± 7.9 cm). All participants completed a Physical Activity Readiness Questionnaire (PARQ) and informed consent form prior to the commencement, and any participant that reported a lower limb injury in the previous 3 months was excluded from the study. Institutional ethical approval (University of Wolverhampton, UK) was granted prior to recruiting volunteers. All participants partook in 2–3 training sessions per week plus one match. All participants were familiar with tests as they were routinely used for both training and to monitor fitness.

2.2. Reactive strength and 505 agility

Participants were randomly assigned to three groups, FIFA 11+ WBV (FIFA + WBV), FIFA 11+ isometric squat (FIFA + IS), and Control (Con) using a sealed envelope method. The tests consisted of a reactive strength index measure (RSI), which includes measurement of jump height and contact time, which have previously demonstrated excellent reliability.²⁸ And a 505 agility test which has also reported good validity and reliability when assessing change of direction speed.^{29,30} The RSI involved the participant performing a maximal counter movement jump following a drop jump from a 30-cm plyometric box. Drop jump height (DJH) and contact time (CT) were recorded using the Opto-jump system (Microgate, Bolzano, Italy) which is considered a valid and reliable alternative to a force platform when assessing jumps.³¹ RSI was calculated by dividing the height jumped by the contact time prior to take-off.³² For the 505 agility test timing gates were placed 5 m from designated turning point. The participants assumed a starting position 10 m from the timing gates (and therefore 15 m from the turning point). Participants were instructed to accelerate as quickly as

possible through the timing gates, pivot on the 15 m line, and return as quickly as possible through the timing gates.²⁹ Times were recorded for each trial using a light gate system (Smartspeed; Fusion Sport, Queensland, Australia). Thomas et al.³³ indicated that the test provided a good indicator of the player's deceleration and change of direction capacity. Each participant completed a familiarisation session the day prior to testing before the mean scores of three trials of each test were recorded pre- and post- intervention on the day of testing.

2.3. FIFA 11+ and vibration intervention

Each group then completed their allocated intervention, and the warm-up consisted of the FIFA 11+. The FIFA 11+ programme consisted of 15 single exercises, divided into three parts including initial and final running exercises with a focus on cutting, jumping, and landing techniques (parts 1 and 3) and strength, plyometric, agility, and field balance components (part 2). For each of the six conditioning exercises in part 2, the 11+ programme offered three levels of variation and progression.¹ For all groups the warm-up was conducted by the same researcher who was experienced in the delivery of the FIFA 11+. Participants were also briefed on all aspects of the warm-up in order to confirm their understanding using material and videos provided online at the 11+ programme website (<http://f-marc.com/11plus/>).

Each group following the FIFA 11+ immediately carried out their allocated intervention (FIFA + WBV, FIFA + IS, and Con). The FIFA + WBV group performed a 100-degree squat (as verified with a clinical goniometer) with their heels elevated and slightly leaning forward to maximise vibration stimulus.³⁴ Participants were exposed to a vertical sinusoidal WBV of 40 Hz with a ± 4 mm amplitude (NEMES Bosco System, Rieti, Italy). The FIFA + IS group completed a 30-s isometric squat with a 100-degree flexion at the knees on the platform (without vibration), and the Control group only completed the FIFA 11+. Participants then completed the RSI test immediately (<15 s) post intervention and the 505 agility 4 min after so as not to effect the results.¹⁹

2.4. Statistical analysis

Descriptive statistics (mean \pm SD) were calculated for DJH, CT, RSI, and 505 agility. A mixed-model repeated-measures ANOVA (group \times time) and Scheffe *post hoc* tests were used to analyse the intervention effect on DJH, CT, RSI, and 505 agility. Statistical significance was set at $p < 0.05$. In addition, to further interpret any differences between means, effect sizes (partial η^2) were calculated and interpreted based on the criteria of Cohen³⁵ where 0.1 is a small effect, 0.25 is a medium effect, and 0.4 is a large effect. The reliability of sprint 505 agility and RSI measures between testing sessions was assessed by intra-class correlation coefficients (ICCs). An ICC value of 0.75 or greater was considered acceptable for reliability.³⁶ ICC between testing sessions (familiarisation and testing) for RSI ($r = 0.90$) and 505 agility ($r = 0.88$) were

Table 1

Drop jump height (DJH), contact time (CT), reactive strength index (RSI), and 505 agility (505) descriptive statistics (mean \pm SD) for each treatment group (FIFA + WBV ($n = 25$), FIFA + IS ($n = 25$), and Control ($n = 24$)).

| Parameters | FIFA + WBV | FIFA + IS | Control |
|----------------------------|------------------|------------------|------------------|
| Pre- DJH (mm) | 101.6 \pm 25.1 | 99.1 \pm 27.9 | 106.1 \pm 21.4 |
| Post- DJH (mm) | 109.1 \pm 26.9 | 98.1 \pm 32.4 | 105.3 \pm 21.0 |
| Pre- CT (ms) | 211.6 \pm 55.9 | 217.4 \pm 85.1 | 209.6 \pm 66.6 |
| Post- CT (ms) ^a | 189.0 \pm 46.5 | 223.4 \pm 81.4 | 211.6 \pm 61.5 |
| Pre- RSI | 0.5 \pm 0.2 | 0.5 \pm 0.2 | 0.5 \pm 0.2 |
| Post- RSI ^a | 0.6 \pm 0.2 | 0.5 \pm 0.2 | 0.5 \pm 0.1 |
| Pre- 505 (s) | 2.8 \pm 0.3 | 2.9 \pm 0.3 | 2.8 \pm 0.3 |
| Post- 505 (s) | 2.8 \pm 0.3 | 2.9 \pm 0.3 | 2.9 \pm 0.3 |

Abbreviations: WBV = whole body vibration; IS = isometric squat; RSI = reactive strength index.

^a indicates a significant time \times group interaction ($p < 0.05$) and a significant difference between groups ($p < 0.05$).

reported. Statistical analysis was done with SPSS software version 19.0 (SPSS, Chicago, IL, USA).

3. Results

Following random allocation of participants no significant baseline differences were identified between treatment groups. Descriptive statistics (mean \pm SD) for the pre- and post- DJH, CT, RSI, and 505 agility of the intervention and control groups are shown in Table 1. There were no main effects due to group or time ($p > 0.05$) for DJH, CT, RSI, or 505 agility, although a number of these dependent variables revealed significant time \times group interactions.

The counter-movement jump data reported no time \times group interaction, although there was a trend ($p = 0.06$) towards the vibration intervention having a greater effect on DJH than the other interventions (Fig. 1). CT reported a significant time \times group interaction ($F(2, 71) = 5.529$; $p = 0.006$, partial

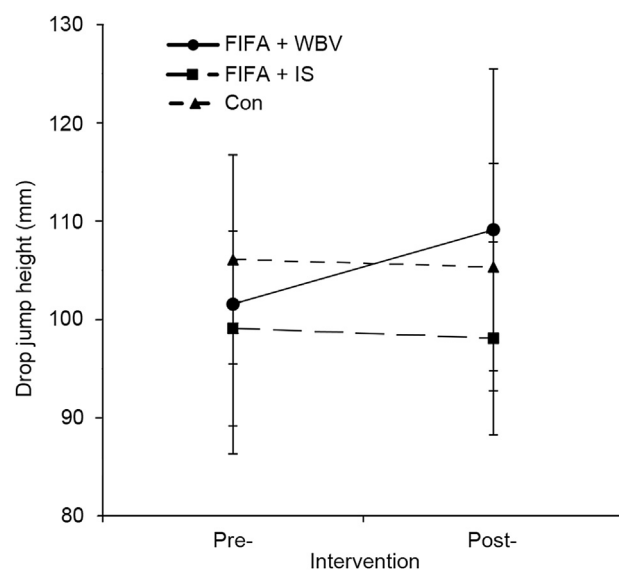


Fig. 1. Change in drop jump height pre- and post- intervention. FIFA 11+ whole-body vibration (FIFA + WBV), FIFA 11+ isometric squat (FIFA + IS), and FIFA 11+ alone (Con) (mean \pm SD). Time \times group interaction ($F(2,71) = 2.123$; $p = 0.127$), with no significant difference between groups ($p > 0.05$).

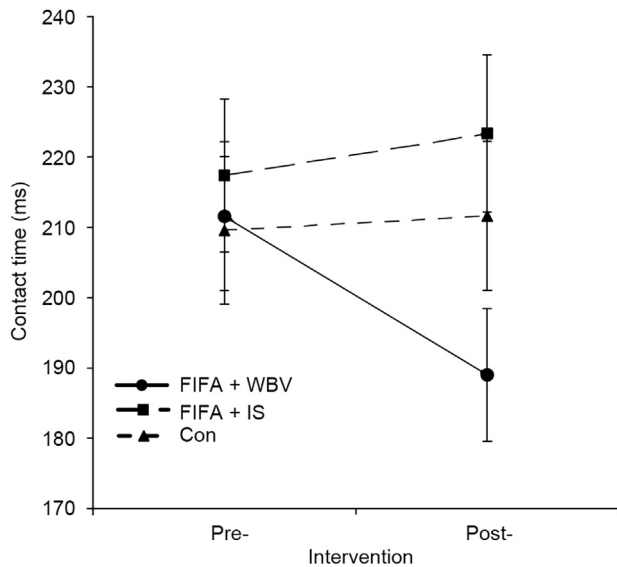


Fig. 2. Change in contact time pre- and post- intervention. FIFA 11+ whole-body vibration (FIFA + WBV), FIFA 11+ isometric squat (FIFA + IS), and FIFA 11+ alone (Con) (mean \pm SD). Time \times group interaction ($F(2,71) = 5.529$; $p = 0.006$, partial $\eta^2 = 0.2$), with a significant difference between groups ($p < 0.05$).

$\eta^2 = 0.2$) with the vibration group significantly decreasing CT compared to the other two groups ($p < 0.05$) (Fig. 2). Despite the lack of a significant DJH effect, the RSI, a measurement based on DJH and CT, reported a significant time \times group interaction ($F(2, 71) = 8.869$; $p < 0.001$, partial $\eta^2 = 0.2$) with *post hoc* tests indicating a significant increase in the vibration group ($p < 0.05$) (Fig. 3).

There was no time \times group interaction for the 505 agility test ($p > 0.05$) although, similar to the DJH data, there was a trend towards the vibration intervention having a greater negative effect on agility (increased time) than the other interventions.

4. Discussion

The current study is the first to look at the effects that the addition of WBV to the FIFA 11+ has on RSI and 505 agility. The aim of the present research was to investigate the benefits of including an acute bout of vibration stimulus following the FIFA 11+ in collegiate soccer players. A well established and successful warm-up has not only benefits to subsequent performance,^{5–7} but also injury prevention.⁸ The FIFA 11+ has been recognised as a well-established tool for reducing injury rates amongst soccer players, however performance improvements following its intervention have not been reported as clearly.^{1,9,10} From the present results the addition of acute vibration to well-established warm-up has shown positive results in RSI through a decrease in CT, however there was no improvement in 505 agility amongst participants. Factors such as reactive strength have been strongly correlated to change of direction efficiency and speed,³⁷ as well as a key distinguishing characteristic between elite and non-elite soccer

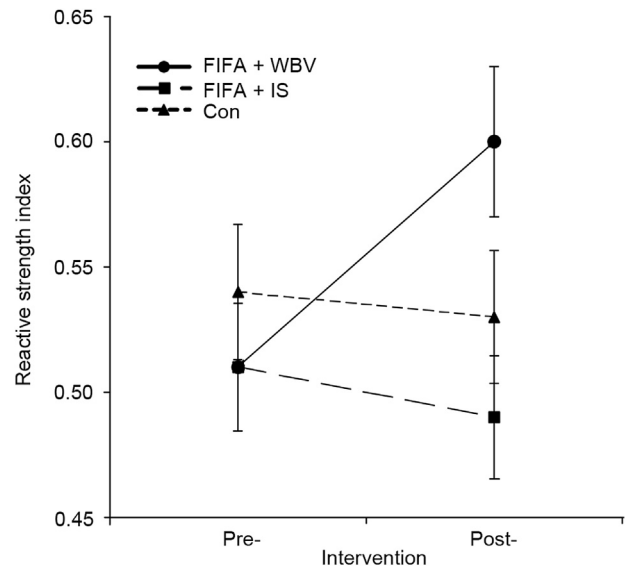


Fig. 3. Change in reactive strength index pre- and post- intervention. FIFA 11+ whole-body vibration (FIFA + WBV), FIFA 11+ isometric squat (FIFA + IS), and FIFA 11+ alone (Con) (mean \pm SD). Time \times group interaction ($F(2,71) = 8.869$; $p < 0.001$, partial $\eta^2 = 0.2$), with a significant difference between groups ($p < 0.05$).

players.³⁸ Such acute improvements in these characteristics should therefore welcomed by players and coaches.

The determination of physiological mechanisms responsible for the significant acute changes that took place following different warm-up protocols is beyond its scope of the present study as no direct neuromuscular responses were measured. The changes in RSI however indicate that there has been a neuromuscular response due to WBV which will be discussed and suggestions made to why this may have occurred. As identified in previous research one potential explanation for the improvements in RSI (through a reduction in contact time) is due to increased efficiency in the stretch shortening cycle (SSC).²⁴ In particular an improvement in the short-latency stretch reflex would mean a significant reduction in CT, as this corresponds to the reflex after ground contact.³⁹ Vibration training as a mechanical stimulus has been linked to an improvement in latency stretch reflex post vibration.^{40,41} Increased muscle spindle sensitivity and a decrease in recruitment threshold of motor units could also be suggested as a key factor for the decreases in CT,⁴² with an increase in spindle sensitivity improving detection on landing and a lowering of recruitment threshold meaning an increase in the velocity of contraction.⁴²

The above argument however, of an increase in short-latency stretch reflex and a decrease in recruitment threshold are questioned by the current findings. Such neuromuscular changes could also benefit the 505 agility time but this was not the case. An alternative explanation for the present results may have to do with the suppression of muscle spindle activity. Ritzmann et al.⁴³ suggested that an increase in muscle stiffness (and thus reflex response) in the muscles involved during jumping was due to the suppression of Ia afferent transmissions from muscle spindles following vibration stimulus by

the supraspinal centres. Ritzmann et al.⁴³ discussed the idea that vibration stimulus has been linked to suppression of Ia afferent pathways caused by pre activation.⁴⁴ However, as the SSC is a combination of Ia afferent inputs and cortical contribution,⁴⁵ the current results may suggest that an increase in cortical contribution (via supraspinal centres) compensates for a reduction in Ia afferent transmission. More importantly, for the current research this may explain the difference in improvements between RSI and 505 agility time. Ritzmann et al.⁴³ suggested that depending on the complexity of the motor task there was a greater cortical contribution and a reduction in Ia afferent recovery time. Therefore it could be argued that the motor complexity of the drop jump protocol during the RSI protocol was greater than that of the 505 agility protocol and therefore benefited from this.⁴³ Although positive results have been seen in 30 s WBV exposure¹⁶ in power and jump ability the relatively small exposure could be the reason for no increase in 505 agility as previously reported.³⁰ An increase in vibration exposure may have improved these agility values. However, although not significant, a negative trend in 505 agility was recognised. So any increase in exposure may have accelerated this worsening in performance due to fatigue.⁴⁶

The primary aim of the present study was to investigate the effects of acute vibration stimulus on a well-established warm-up routine (FIFA 11+). The results presented show that the addition of 30 s of vibration training immediately (<90 s) post FIFA 11+ had significant effect on CT and RSI, however no overall change in DJH or 505 agility. This is the first study to combine the two interventions to test performance outcomes amongst soccer players and future research should investigate (1) the exact mechanism behind such improvements amongst different abilities as clear differences exist between trained and untrained athletes and responses to WBV,⁴⁷ and (2) the time span of any improvements over the course of the athlete's chosen activity to improve ecological validity. What is clear is that the neuromuscular response to acute vibration stimulus following a dynamic warm-up needs further investigation, in particular amongst a range of populations and performance outcomes.

5. Conclusion

Much debate still surrounds the acute effects of WBV on subsequent performance enhancement. Amongst collegiate soccer players 30 s WBV at 40 Hz following FIFA 11+ improves RSI and has no negative effects on 505 agility. These positive trends suggest that the inclusion of WBV plates may be a useful addition to a post warm-up area either pitch side or training room based, to provide additional benefits to the FIFA 11+. A note of caution is recommended, however, further investigation is warranted into the time course of such benefits and the exact mechanism behind such improvements. Also, the apparent negative trend in agility needs further investigation, as one of the key criticisms for the additions of exercises to the FIFA 11+ is the risk of fatigue leading to a worsening in performance.¹⁰ Although

the increase in agility time was not significant, from a practical perspective this requires further investigation. What is clear is that WBV provides real scope as a beneficial addition to an already well-established warm-up routine, with strength and conditioning coaches using the novelty of such equipment as a factor for increased adherence and compliance.

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